# COMPARISON OF IN-SITU, MODEL AND GROUND BASED IN-FLIGHT ICING SEVERITY

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NCAR National Center for Atmospheric Research

NASA National Aeronautics and Space Administration

## Overview

- In-flight icing (IFI) is a signficant hazard for the aviation industry.
- IFI occurs when supercooled liquid water (SLW) comes in contact with, and freezes to, the leading surfaces of an aircraft.
- Significantly alters aircraft aerodynamic properties:
  - Increases the amount of drag on an aircraft
  - Reduces the lift

- Currently there are two systems that are being developed for the detection of in-flight icing:
  - -NASA Icing Remote Sensing System (NIRSS)
  - -Current Icing Product (CIP)

- The objective of this study is to examine how the testbed NIRSS icing severity product and the operational CIP severity product compare to PIREPs of icing severity, and how the NIRSS and CIP compare to each other.

## Methodology

- A three year database of CIP, NIRSS and PIREP data which concentrates on winter periods from early November to late March of the years 2008 through 2010 was compiled.
- 917 PIREPS were detected within 40 km horizontal distance from the NIRSS system location near Cleveland-Hopkins International Airport in Cleveland, Ohio.
- CIP products were produced for the closest 20 by 20 kilometer RUC horizontal gridpoint to the NIRSS, and relevant icing severity values were extracted at the time of each icing PIREP.
- Analysis occurred from the ground level to ~30,000 ft. For this study, a PIREP reported over a range of heights is treated as multiple PIREPs spread over 1000 foot increments.

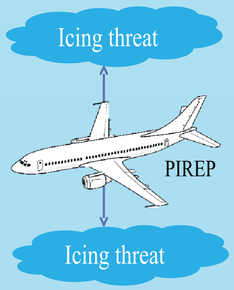
Find PIREP and altitude between ground level & 30,000 feet

↓

Vertically search upwards and downwards through troposphere for nearest icing severity threat

↓

Complete temporal and spatial matching for all PIREPs




## Acknowledgements

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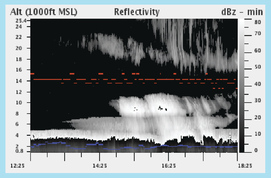
## NASA Icing Remote Sensing System

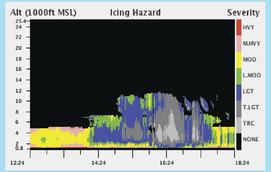
Integrates 3 vertically pointing sensors:

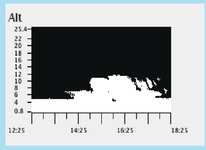
1. Multichannel microwave radiometer
2. Vaisala laser ceilometer
3. Metek Ka-Band radar

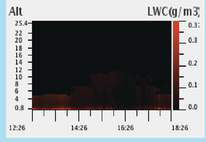
→ These three sensors utilize the derived integrated liquid water (ILW), radar reflectivity, temperature profile, and cloud top and base heights to depict the presence of in-flight icing in the atmopshere.

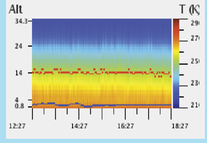
### Looks into and through cloud to find icing hazard

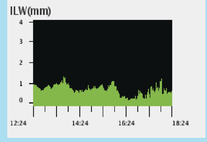




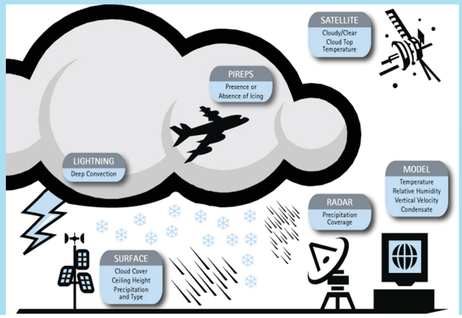

## Current Icing Product

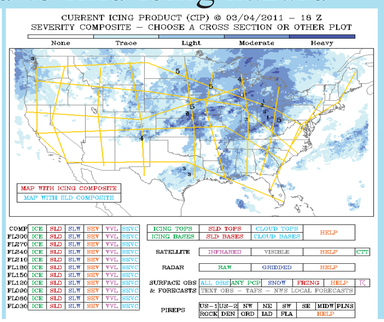
Employs:

1. Visible and infrared satellite imagery
2. Radar reflectivity (composite only)
3. Lightning reports
4. PIlot REPorts (PIREPs)
5. Ground observations (METARs)
6. Rapid Update Cycle (RUC) model variables

→ To produce a gridded, hourly, 3 Dimensional representation of icing probability and severity.

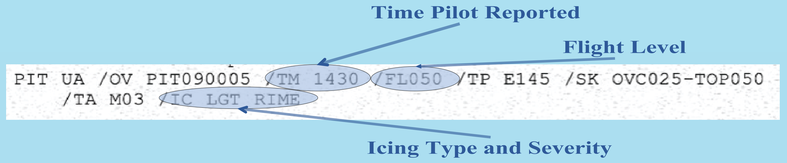
### Does NOT look into cloud to find icing hazard



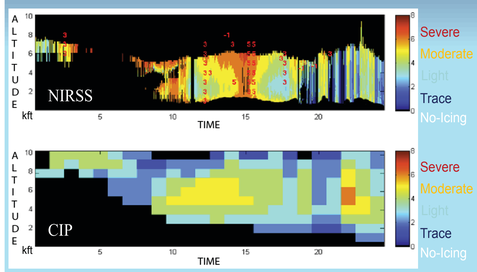

## Pilot Reports

- A PIREP is a report of actual weather conditions encountered by an aircraft in flight. In this study PIREPs are considered as the "truth" dataset.
- PIREPs can sometimes be inaccurate due to time lags before the pilot reports the observed icing condition, and whether he or she reports the correct altitude and location




## Findings

Sample single day comparison (PIREP severity and height are red numbers):




Full 3-year comparison:

| CIP \ PIREP | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 1 | 1 | 0 | 5 | 0 | 4 | 0 | 0 | 0 |
| 6 | 4 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 5 | 5 | 10 | 0 | 21 | 7 | 13 | 0 | 0 | 3 |
| 4 | 12 | 13 | 0 | 78 | 20 | 43 | 0 | 0 | 0 |
| 3 | 22 | 14 | 0 | 94 | 20 | 35 | 0 | 0 | 0 |
| 2 | 32 | 12 | 1 | 97 | 13 | 40 | 0 | 0 | 0 |
| 1 | 38 | 23 | 0 | 92 | 6 | 7 | 0 | 0 | 0 |
| 0 | 47 | 4 | 0 | 47 | 0 | 22 | 4 | 0 | 0 |

CIP versus PIREP icing severity:
- PODy = 0.90, PODn=0.29
- severity category correlation 0.21
- Warn volume 34%

| NIRSS \ PIREP | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 |
| 6 | 1 | 1 | 0 | 18 | 4 | 29 | 0 | 0 | 0 |
| 5 | 1 | 7 | 0 | 28 | 8 | 23 | 0 | 0 | 0 |
| 4 | 1 | 5 | 0 | 46 | 7 | 15 | 0 | 0 | 0 |
| 3 | 6 | 18 | 0 | 95 | 18 | 22 | 0 | 0 | 0 |
| 2 | 9 | 20 | 0 | 71 | 3 | 28 | 0 | 0 | 1 |
| 1 | 28 | 10 | 1 | 71 | 12 | 14 | 0 | 0 | 2 |
| 0 | 115 | 19 | 0 | 93 | 16 | 34 | 4 | 0 | 0 |

NIRSS versus PIREP icing severity:
- PODy = 0.78, PODn=0.71
- severity category correlation 0.35
- Warn volume 13%

* Prototype NIRSS does nearly as good as operational CIP at icing and much better at non-icing detection in

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